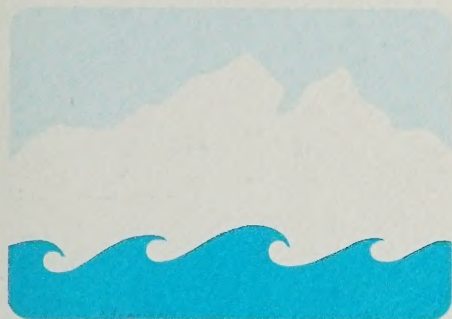


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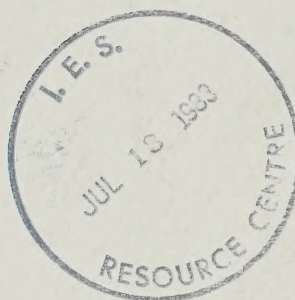


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A Preliminary Baseline Study of Roberts and Sturgeon Banks

by

C.A. Bawden, W.A. Heath
and A.B. Norton



University of British Columbia
Vancouver 8, Canada



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A Preliminary Baseline Study of
Roberts and Sturgeon Banks*

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C.A. Bawden, W.A. Heath
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Westwater Research Centre
University of British Columbia
Vancouver 8, Canada

Technical Report No. 1

The project described herein was undertaken as part of a much larger program on the biological, physical and socio-economic aspects of the Lower Fraser River. The project was supported by the Westwater Research Centre and conducted under the guidance of Dr. T. Parsons, Institute of Oceanography, University of British Columbia.

* Also identified as Institute of Oceanography Manuscript No. 27.

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I. INTRODUCTION

The purpose of this study was to determine the species content of the fauna found in the tidal flat areas of Roberts and Sturgeon Banks, and to assay the most numerous larger organisms for heavy metal and pesticide residues. It was intended, therefore, that the study would serve as a description of the tidal flat animal community in 1972 and indicate the baseline level of pollutants in the larger more common animals.

The banks can be reached either by boat or from the shoreline. The area is uncovered by the tide for a few hours each day, the extent of exposure depending on the tidal cycle at that time. Since the sampling of organisms in the sediment had to be carried out when the flats were exposed, the time available for sampling on any one day was limited. In addition, bulky sampling equipment had to be carried over a difficult terrain consisting in part of soft sediment and deep channels dividing up the area. One solution to these logistic difficulties was to use the causeways (see Fig. 1) as a means of access to the area. Except in the immediate region of the rock deposits, the causeways have not in themselves disturbed the mud flats. These facilities were generally used, therefore, when a number of collections were made over a relatively short distance.

Stations were occupied at approximately two mile intervals (depending on local conditions) over the entire length of the flats except in the vicinity of the Iona Island sewage channel. In addition, station transects (e.g. E 1, E 2, E 3, and E 4) were occupied to show local variations in fauna. Some stations appear to be located close to shore relative to the low water mark (Fig. 1); however, the latter line represents the lowest tide mark which was only uncovered briefly every two weeks during the three month study period. The mean low water mark would be represented on Fig. 1 as a line approximately $\frac{1}{3}$ to $\frac{1}{2}$ of the distance from the lowest tide mark towards the shore, depending on the local terrain. Sampling of the lowest part of the banks was carried out by SCUBA diving, the predominant animals collected on these dives being crabs. A total of 39 stations were sampled, 80 animals were collected for heavy metal analysis, and 40 animals for pesticide analysis. In addition, water samples were taken from a mid-stream position off the end of Steveston Jetty; these samples were analysed for oxygen, nutrients and chlorophyll in order to provide background information on the quality of water covering the flats during each tidal cycle.

The report is presented as a collection of original data and no attempt has been made to bias the interpretation of these results by statistical treatment. For the reader's benefit, however, we have included some results of findings in other estuaries as well as the levels of pollutants found in some other biological materials.

The authors of this report are grateful to the Captain and crew of C.S.S. vessel "Vector" for assistance in obtaining water samples and to Dr. J. Thompson for crab samples from Kitimat Arm.

II. METHODS

There follows a description of the methods used in developing the data presented in this report.

A. HEAVY METAL AND CHLORINATED HYDROCARBON RESIDUE ANALYSES

In order to monitor most effectively the amount of heavy metal and chlorinated hydrocarbon residues in the fauna of the Fraser River tidal flats, as large a variety of organisms as possible was collected, without straying far from those species which were commonest and/or commercially most important to man. Heavy metal and chlorinated hydrocarbon values derived from this faunal collection were compared with metal and hydrocarbon values from two other collecting areas. These were the Cowichan River Delta, Vancouver Island, B.C. (48°45'N, 123°37'W), which contains much the same fauna as the Fraser Delta and is relatively free from sources of industrial pollution, and Kitimat Arm, B.C. (53°58.5'N, 128°39.3'W), where one species of crab which is common to the Fraser Delta area was obtained for the purpose of residue comparison.

Field Sampling

On the Fraser and Cowichan River deltas, field sampling involved littoral and sublittoral (SCUBA) macrofauna collections. Samples were either temporarily frozen or immediately prepared for the appropriate analysis. Kitimat Arm samples were sent in a frozen state to the Pacific Environment Institute, West Vancouver, and then transferred in the same state to the Institute of Oceanography, U.B.C.

Laboratory Work

Heavy Metals

- Tissue Preparation. Tissue analysis was carried out for the elements Silver (Ag), Cadmium (Cd), Cobalt (Co), Copper (Cu), Mercury (Hg), Manganese (Mn), Nickel (Ni), Lead (Pb), and Zinc (Zn). Preparation of whole samples or appropriate sample tissues involved homogenizing by hand or Waring © blender, freezing, and then vacuum drying in a Virtis © freeze dryer. All dried samples were then ground with a mortar and pestle to a fine powder to pass through a U.S. Standard Sieve Mesh #80. Samples were then stored for analysis in glass vials in approximately 1 to 2 g quantities. Excluding the sieve, all equipment for handling and storing of samples was washed with hydrochloric acid of an appropriate dilution. The sieve was washed thoroughly with distilled water.

- Analytical Methods. A 0.25 to 0.60 g (dry powdered weight) sample was digested with concentrated nitric acid, evaporated to dryness and the residue taken up in 20 ml of 1.5 M hydrochloric acid. These solutions were analysed by an atomic absorption spectrophotometer (Techtron AA-4 and Perkin Elmer Model 303) for all elements. Lead was determined colorimetrically. Analyses were performed under contract by Mr. R. Leary, Department of Geological Sciences, University of British Columbia.

- Mercury Method. A 0.2 g (dry powdered weight) sample was digested with H_2SO_4 and H_2O_2 . Excess peroxide was removed using KMnO_4 . The solution was then aerated after addition of stannous chloride and the mercury released was analysed in a flameless cell on a Jarrell-Ash atomic absorption spectrophotometer.

Chlorinated Hydrocarbons

- Tissue Preparation. Tissue samples were analysed for residues of the pesticides heptachlor, dieldrin, pp'-DDE, pp'-DDD, pp'-DDT; and of the polychlorinated biphenyls, Aroclor 1254 and 1242. Samples, or appropriate sample tissues, were washed in distilled water and stored frozen in specially prepared "sterile" jars. All other handling equipment was washed thoroughly in acetone.

- Analytical Methods. 100 to 500 mg samples of tissue were analysed by gas liquid chromatography following specific procedures. Analyses were carried out under contract by Dr. P.C. Oloffs, Department of Biological Sciences, Simon Fraser University, Burnaby, B.C.

B. MACROFAUNA - QUANTITATIVE SAMPLING

Quantitative measurement of macrofauna at each station was accomplished by sinking a square, open-ended aluminum box (open end dimensions, 50x50 cm) as far as possible into the substrate. The contents of the box were then shovelled out and washed with sea water through a 0.4 cm wire mesh. The depth of sampling was recorded and all fauna remaining on the sieve were retained for preservation and subsequent identification and counting.

C. MEIOFAUNA - QUANTITATIVE SAMPLING

Meiofauna sampling was carried out by inserting an open-ended glass tube (4 cm in diameter, 10 cm long) approximately 8 cm into the substrate. The tube was removed from the substrate with the core inside, and retained in an upright position in a plastic bag until it was returned to the laboratory. In the laboratory, the core was either temporarily frozen (to prevent meiofauna vertical migration) or sectioned. Sectioning involved pressing the bottom end of the core and pushing it up through the tube. As the surface of the core emerged above the tube, every 0.5 cm (down to 2.0 cm) was measured, cut off, and preserved for study in a glass jar.

In order to identify and enumerate the meiofauna organisms, it was necessary to separate them from their corresponding sediment sections; this being achieved by a process of elutriation. An aluminum trough (90 cm long) was set up in a horizontal position with one end slightly raised. A stream of water was introduced into the raised end of the trough and a nylon mesh was suspended under the other end to receive the outflow of water. A 0.5 cm substrate section was then introduced at the raised end of the trough. Sand and mud particles were mixed and washed with the inflowing water for 12 minutes. While heavier sand particles remained in the length of the trough, the lighter meiofauna organisms and detritus were carried out of the trough and into the receiving mesh. Contents of the mesh were then

washed into a dish to be sorted and counted under a dissecting microscope. The length of time involved in sorting samples made it impossible to enumerate all organisms. The organisms were therefore grouped into the most numerous faunal divisions which were copepods, nematodes, and annelids.

D. CHLOROPHYLL a DETERMINATION

Field

The bottom of a 8.5 cm diameter plastic petri dish was inverted into the substrate and filled by pressing down. The surrounding substrate was cleared away from the outside of the dish, and the cover placed into position. Thus, a "core" 1 to 2 cm deep and 8.5 cm in diameter was obtained.

Laboratory

The "core" was halved vertically (only one half being used for analysis). The sample half was drained of water by vacuum filtration and chlorophyll was extracted from the sand and filtered in 50 ml of 90% acetone solution containing about 0.5 g MgCO_3 . Following extraction, samples were held at ca 5°C in the dark for 24 hours; samples were then centrifuged. The extinctions of subsamples of the extracts were determined in 1 cm cells using a Perkin-Elmer Double Beam Spectrophotometer (Model: Coleman 124 D) at wavelength of 665 nm and 750 nm. The amount of chlorophyll a per square meter was calculated from the expression

$$\mu\text{g chl } \underline{a} / \text{m}^2 = 11.6 (E_{665} - E_{750}) \cdot \frac{\text{Vol. extract in ml}}{\text{Sfc. area of sediment in m}^2}$$

This equation is adapted from Strickland and Parsons (1968).

E. TEMPERATURE

Temperatures in °C were taken in the top 2 to 3 cm of substrate at each station.

F. SALINITY

Field and Laboratory

Water samples were taken either interstitially (on exposed flats) or from the water of surface pools or the rising tide. Interstitial samples were collected by inserting a plastic centrifuge tube, apex first, 4 cm into the substrate. Interstitial water entered through holes which had been drilled around the circumference of the tube near its apex. The water was stored in standard salinity bottles or in glass jars until salinity measurement was possible. When substrates below the water level were sampled for salinity, water was scooped up directly into salinity containers. A portable salinometer (YSI, Model 33, S-C-T) was used to measure salinity.

G. GRAIN SIZE ANALYSIS

Field

The grain size sampling area at each station was in close association with the meiofauna sampling area. A 2 or 4 oz. jar was inverted and pushed fully into the substrate, the jar then being sealed and stored for analysis.

Laboratory

Samples were oven-dried and passed through a series of U.S. Standard Sieve meshes (see Table 3). Particle sizes represented by the meshes ranged from very coarse sand to very fine sediment. Subsamples obtained from each sieve were categorized into different grades as a percentage weight of the whole sample.

H. WATER SAMPLES

Water samples were collected from the main arm of the Fraser River as it enters the sea off the end of Steveston Jetty (Sand Heads Light). Samples were collected from C.S.S. vessel "Vector", using Van Dorn bottles. A Beckman T/S meter was used to measure temperature and salinity. Details of other analyses are given on the page preceding the tabulated results of this section.

III. DISCUSSION

The data presented here on the biological community of the Fraser River estuary serve as a record of the state of the mudflats at the time of this study (1972). Quantitative measurements of macro and meiofauna offer comparison for any future studies done in the same area. Background ecological parameters examined in conjunction with the biota monitoring program (eg. temperature, salinity, chlorophyll *a* and grain size) provide base line measurements which could aid attempts to trace the causes of any future changes in the basic biological structure of the mudflats. This discussion is only intended as a guide to the type of data in the Tables and little attempt is made to draw conclusions. However, primary publications involving the interpretation of data may be prepared at a later date using the results reported here.

The infauna community of the Fraser River estuary (Table 1) closely resembles the Macoma nasuta-Macoma secta habitat described by Hedgpeth (1957) in his discussion of bottom communities. This suggests that the studied community is a relatively normal one and is as yet unaffected by present Fraser River or estuarine developments.

Correlations between species content of the sand and physical parameters were evident. For example, Table 4 shows the major species distributions with respect to sand grain size. From these data it is apparent that the mollusc, Cryptomya californica, and the polychaete, Hemipodus borealis, were found in fine grain sediments, while the crustacean, Callianassa californiensis, was more abundant in coarse grain sediments. Stations located close to freshwater outflow (stations U and W, Table 5) exhibited an almost complete absence of macrofauna.

The meiofauna (Table 2) primarily consisted of three major groups of organisms, oligochaeta and nematode worms and harpacticoid copepods. The copepod data reveal that 65 to 99% of these animals occurred within the top 0.5 cm of sand. Oligochaetas and nematodes were generally most abundant near the surface too, but occasionally relatively dense populations were located at depths of 1.0 to 2.0 cm.

The population densities of these meiofauna groups observed in the present survey expressed as numbers of animals per centimeter of sediment surface, are comparable to those found by investigators in other intertidal mudflat environments. In the Fraser estuary, densities of nematodes ranged from 0.5 to 55 cm⁻², while Moore (1931) found 25 nematodes cm⁻² at his Loch Head station in the Clyde Sea. Rees (1940) estimated densities of 7 to 1,040 nematodes cm⁻² in a eutrophied mudflat in Bristol Channel. Rees also found from 7 to 78 oligochaetas cm⁻² as compared to densities of 0.2 to 37 cm⁻² in the present study. For the copepod populations, Moore (1931) counted 7 harpacticoids cm⁻² at Loch Head; Rees (1940) estimated 5 to 50 cm⁻² and Heath (1972, unpublished) observed 2 to 19 adult harpacticoids cm⁻² in sediments from Mud Bay, B.C. Sediments from the Fraser estuary flats yielded from 2 to 33 copepods cm⁻². These results indicate that the meiofauna community of the Fraser River mudflats (excluding the immediate area of the Sewar outfall) is a natural community which is not at present showing any effects of eutrophication.

The general feature of the data reported in Table 6 on heavy metal content of the macrofauna is that, with one or two exceptions, heavy metals were only found in significantly high concentrations in animals from the Sturgeon Bank area. Thus out of 27 samples of crab having a carapace width of greater than 110 cm, 8 crabs taken from Sturgeon Bank had a mercury content approximately seven times the amount found in crabs taken from Roberts Bank, Cowichan Bay or Kitimat Arm. However, crabs taken from Sturgeon Bank of less than 110 cm carapace width (1 to 2 year old animals) did not show this high mercury content. Similarly 5 separate collections of molluscs taken from Sturgeon Bank had a mean mercury content of 0.33 ppm compared with 7 collections from Roberts Bank and the Cowichan estuary which had a mean mercury content of 0.12 ppm. High silver contents were also noted in 5 animals from Sturgeon Bank; cadmium was less than 2 ppm in all samples except 4 samples from Sturgeon Bank and 2 from Roberts Bank. Copper was highly variable depending on the species of animal analysed, but the highest range of values was found in animals from Sturgeon Bank. Cobalt, manganese, nickel, lead and zinc did not show any specific pattern of high or low values which could be related to geographical area.

While the data in Table 6 provide an intercomparison of values between different areas, it is difficult to compare them with specimens analysed by other scientists. In general there is a paucity of such data when one searches for the same or even similar species, particularly with reference to benthic communities. Some data have been accumulated in Table 9 and the maximum permitted levels for marketable produce are also given, in as far as these are known. Since the latter values are given in "market weight" it is necessary to divide by 5 the values in Table 6 for crabs and shrimps, and by 20 for molluscs, in order to obtain an approximate conversion of dry weight to "market weight".

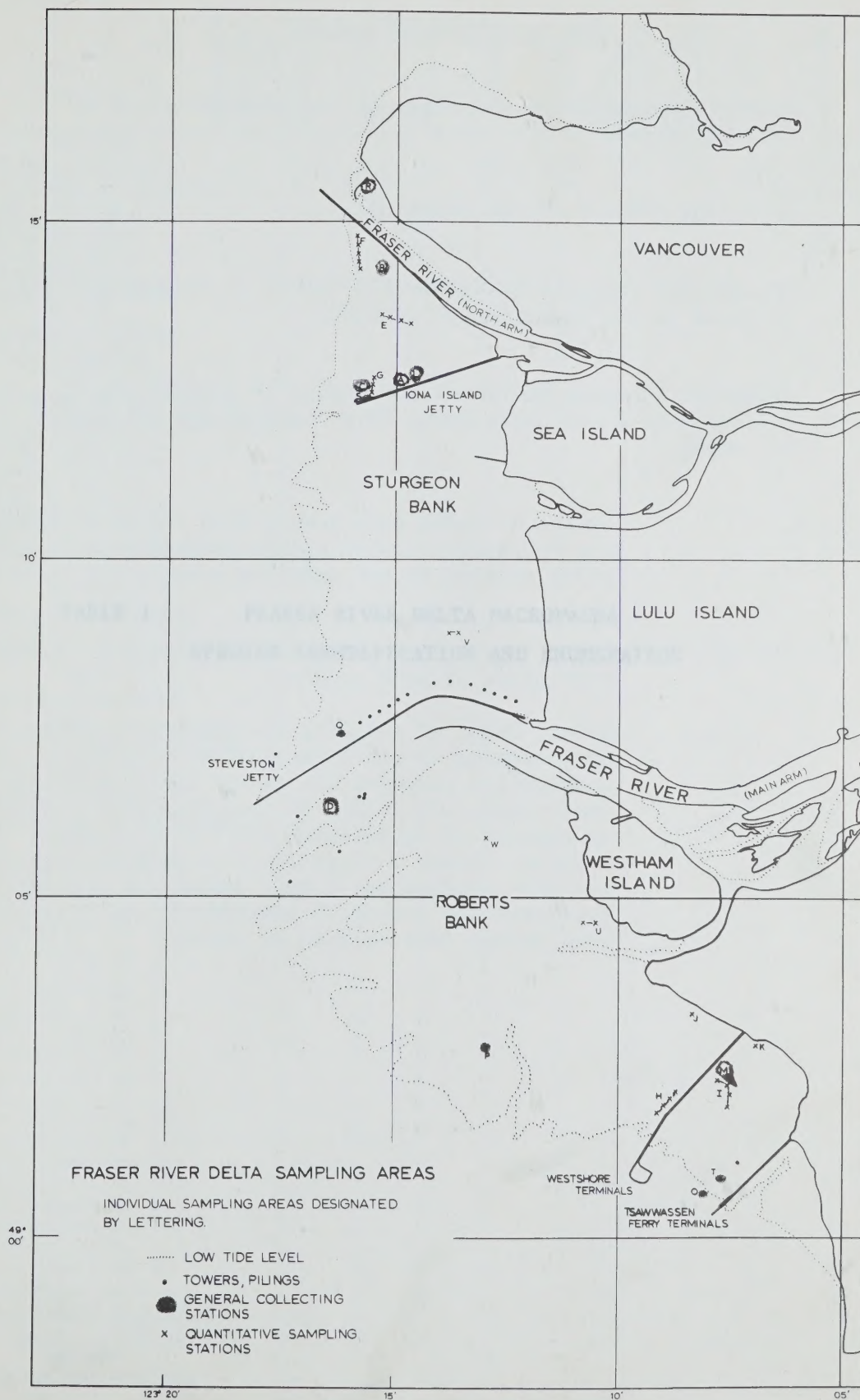
Pesticide and PCB levels given in Table 7 are largely useful for inter-comparisons between areas. Maximum permissible levels of these compounds vary widely with the produce (World Health Organisation (1972)). For example DDT (or derivatives DDD, DDE) in shell-free eggs is permitted below 0.5 ppm but in milk the level must be below 0.05 ppm. The level of PCB to be permitted in foods has not been established to date, but it is apparent from Table 7 that this compound is higher in all specimens of crab in the Strait of Georgia compared with specimens from Kitimat Arm.

Data in Table 8 provide background information on the nutrients, phytoplankton, oxygen, temperature and salinity of water at Sand Heads Light. These data reflect the content of salt and freshwater as it mixes at the mouth of the main arm of the Fraser and flows from there over Roberts and Sturgeon Banks. The data do not indicate any enrichment of estuarine water with inorganic nitrogen and phosphorus coming from the river. In addition oxygen levels were generally high, except for one low value, in low salinity surface water during August.

Supplementary Station identification for Figure 1.

Lines of Stations lettered E, F, G, V, U, H and I were numbered as follows:

E 1, 2, 3 and 4 starting at the western end with E 1
F 1, 2, 3 and 4 starting at the northern end with F 1
G 1, 2 and 3 starting at the southern end with G 1
V 1 and 2 starting at the western end with V 1
U 1 and 2 starting at the western end with U 1
H 1, 2, 3 and 4 starting at the southern end with H 1
I 1, 2, 3 and 4 starting at the southern end with I 1.



KEY TO MACROFAUNA TABLES

- + Indicates presence of the organism, no quantification or collection made.
 - Indicates absence of the organism.
 n Unbracketed integers designate the number of individuals obtained in the quantitative sampler.
 (n) Bracketed integers designate the number of individuals collected on a selective basis (i.e. hunting specifically for them).

Cruise, Area Cruise or field trip number with location keyed to map by letter; number suffix referring to a particular station in the sampling area.

Depth (cm)/Vol.(m³) Depth to which quantitative sampling was carried out/volume of sand sampled.

Note: Depth of sampling and therefore volume of sand sampled varied from station to station. For comparative purposes all values for numbers of individuals per volume of sand have been normalized to numbers of individuals per 0.1 M³ of sand. However, values for species more common to sand surfaces (Cerithium, Crago, amphipods, and fishes) represent the number of individuals per original sand volume (see margins of table).

[illegible]

SPECIES	Cruise, Area Depth (cm) / Vol. (m ³)	F.VI, F-4 19 / 0.05	F.VI, F-5 10 / 0.025	F.VII, G-1 18 / 0.045	F.VII, G-1b 28 / 0.07	F.VII, G-2 20 / 0.05	F.VII, G-3 15 / 0.04	F.VIII, H-1 15 / 0.04	F.VIII, H-2 15 / 0.04	F.VIII, H-3 15 / 0.04	F.VIII, H-4 16 / 0.04
Bivalves											
<u>Tellina carpenteri</u>		22	124	167	153	130	168	168	240	400	635
<u>Cryptomya californica</u>		68	100	-	1	126	35	338	128	285	3
<u>Mya arenaria</u>		-	-	-	-	-	-	-	5	3	35
<u>Cardium corbis</u>		-	-	-	-	-	-	-	3	-	8
<u>Mytilus edulis</u>		-	-	-	(20)	-	-	-	-	-	-
<u>Macoma nasuta</u>		-	-	-	-	-	-	-	-	-	-
<u>Crassostrea gigas</u>		-	-	-	-	-	-	-	-	-	-
Snails											
<u>Cerithium moerchi</u>		-	-	-	-	-	-	-	-	-	1
<u>Thais lamellosa</u>		-	-	-	-	-	-	-	-	-	-
Crabs & Shrimp											
<u>Hemigrapsus oregonensis</u>		-	-	-	-	-	-	-	-	-	-
<u>Callinassa californiensis</u>		-	4	-	1	6	-	-	(5)	-	-
<u>Crago alaskensis</u>		-	-	-	-	-	-	-	-	-	-
<u>Crago nigricauda</u>		-	-	-	-	-	-	2	-	2	9
<u>Cancer magister</u>		-	-	-	-	-	-	-	-	-	-
<u>Cancer productus</u>		-	-	-	-	-	-	-	-	-	-
<u>Pinnixa tubicola</u>		-	-	-	-	-	-	-	3	-	-
<u>Upogebia pugettensis</u>		-	-	-	-	-	-	(5)	-	8	-
<u>Pugettia producta</u>		-	-	-	-	-	-	-	-	-	-
Amphipods											
<u>Ampithoe humeralis</u>		-	-	1	2	1	-	-	2	-	-
<u>Amphipod sp. A (unid.)</u>		-	-	-	1	3	-	-	-	-	-
<u>Amphipod sp. B (unid.)</u>		-	-	-	1	-	-	-	-	-	-
Isopod											
<u>Argeia pugettensis</u>		-	4	-	-	2	-	-	-	-	-
Fish											
<u>Citharichthys stigmaeus</u>		-	-	-	-	-	-	-	-	-	-
<u>Clevelandia ios</u>		-	-	-	-	-	-	2	1	3	3
<u>Leptocottus armatus</u>		-	-	-	-	-	-	-	-	-	-
<u>Clinocottus acuticeps</u>		-	-	-	-	-	-	-	-	-	-
<u>Syngnathus griseolineatus</u>		-	-	-	-	-	-	-	-	-	-
Polychaetes											
<u>Hemipodus borealis</u>		-	8	-	-	8	-	8	-	13	3
<u>Abarenicola pacifica</u>		-	-	-	-	-	-	-	-	-	23
<u>Polychaete sp. A (unid.)</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. B</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. C</u>		-	-	-	-	-	-	-	-	3	-
<u>Polychaete sp. D</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. E</u>		-	-	-	-	-	-	-	-	13	10
<u>Polychaete sp. F</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. G</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. H</u>		-	-	-	-	2	-	-	-	-	-
<u>Polychaete sp. I</u>		-	-	-	6	18	-	-	-	-	-
<u>Polychaete sp. J</u>		-	-	-	3	2	-	-	-	-	-
<u>Polychaete sp. K</u>		-	-	-	-	6	-	-	-	-	-
<u>Polychaete sp. L</u>		-	-	-	-	14	-	-	-	-	-
<u>Polychaete sp. M</u>		-	-	-	3	8	-	-	-	-	-
<u>Polychaete sp. N</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. O</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. P</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. Q</u>		-	-	-	-	-	-	-	-	-	-
<u>Polychaete sp. R</u>		-	-	-	4	-	-	-	-	-	-
Nemertine sp. A (unid.) </											

SPECIES	Cruise, Area	Depth (cm) / Vol. (m ³)	F. IX, I-1 18 / 0.045	F. IX, I-2 11 / 0.03	F. IX, I-3 17 / 0.04	F. IX, I-4 20 / 0.05	F. X, J-1 6 / 0.015	F. X, K-1 8 / 0.02	F. X, K-2 10 / 0.025	F. XI, L	F. XII, M	COWN. I, N-1	COWN. II, N-2
Bivalves													
<u>Tellina carpenteri</u>			22	43	5	20	60	-	-	-	-	-	-
<u>Cryptomya californica</u>			300	220	183	208	-	-	-	-	-	-	-
<u>Mya arenaria</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Cardium corbis</u>			(1)	-	-	-	-	-	-	-	-	-	(1)
<u>Mytilus edulis</u>			(15)	-	-	-	-	-	-	(15)	-	-	-
<u>Macoma nasuta</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Crassostrea gigas</u>			-	-	-	-	-	-	-	-	(3)	-	-
Snails													
<u>Cerithium moerchi</u>			-	-	-	-	-	5	1	-	-	-	-
<u>Thais lamellosa</u>			-	-	-	-	-	-	-	-	-	-	-
Crabs & Shrimp													
<u>Hemigrapsus oregonensis</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Callinassa californiensis</u>			-	-	3	2	-	-	-	(5)	(2)	-	-
<u>Crago alaskensis</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Crago nigricauda</u>			-	-	1	-	-	-	-	-	-	-	-
<u>Cancer magister</u>			-	-	-	-	-	-	-	-	-	-	(5)
<u>Cancer productus</u>			-	-	-	-	-	-	-	-	-	-	(2)
<u>Pinnixa tubicola</u>			-	7	5	-	-	-	-	-	-	-	-
<u>Upogebia pugettensis</u>			-	-	3	-	-	-	-	-	-	-	-
<u>Pugettia producta</u>			-	-	-	-	-	-	-	-	-	-	-
Amphipods													
<u>Ampithoe humeralis</u>			1	1	-	-	7	1	-	-	-	-	-
Amphipod sp. A (unid.)			-	-	-	-	-	-	-	-	-	-	-
Amphipod sp. B (unid.)			-	-	-	-	-	-	-	-	-	-	-
Isopod													
<u>Argeia pugettensis</u>			-	-	1	-	-	-	-	-	-	-	-
Fish													
<u>Citharichthys stigmaeus</u>			-	-	1	-	-	-	-	(12)	-	-	-
<u>Clevelandia ios</u>			-	-	1	-	-	-	-	-	-	-	-
<u>Leptocottus armatus</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Clinocottus acuticeps</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Syngnathus griseolineatus</u>			-	-	-	-	-	-	-	-	-	-	-
Polychaetes													
<u>Hemipodus borealis</u>			49	50	43	38	-	-	-	-	(7)	-	-
<u>Abarenicola pacifica</u>			-	-	-	-	-	-	12	-	(12)	-	-
Polychaete sp. A (unid.)			-	-	-	-	-	-	4	-	-	-	-
Polychaete sp. B			2	-	-	-	-	-	-	-	-	-	-
Polychaete sp. C			4	-	-	-	-	-	-	-	-	-	-
Polychaete sp. D			2	-	-	-	-	-	-	-	-	-	-
Polychaete sp. E			4	-	-	-	-	-	-	-	-	-	-
Polychaete sp. F			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. G			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. H			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. I			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. J			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. K			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. L			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. M			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. N			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. O			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. P			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. Q			-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. R			-	-	-	-	-	-	-	-	-	-	-
Nemertine sp. A (unid.)			-	-	-	-	-	-	-	-	-	-	-
<u>Evasterias troschelii</u>			-	-	-	-	-	-	-	-	-	-	-
<u>Pisaster ochraceus</u>			-	-	-	-	-	-	-	-	-	-	-
Sea pen													
<u>Leioptilus guernevi</u>			-	-	-	-	-	-	-	-	-	-	-

SPECIES	Cruise, Area Depth(cm) / Vol. (m ³)	F. XIII, O	F. XIV, P-1	F. XIV, P-2	F. XV, Q	F. XVI, Q	F. XVII, R	F. XVIII, S	F. XIX, T	F. XX, U 19 /0.05	F. XXI, V-1 20 /0.05	F. XXI, V-2 20 /0.05	F. XXI, W 21 /0.05
Bivalves													
<u>Tellina carpenteri</u>		-	-	-	-	-	-	-	-	-	168	166	6
<u>Cryptomya californica</u>		-	-	(1)	-	-	-	-	-	-	-	-	-
<u>Mya arenaria</u>		(1)	-	-	-	-	-	-	-	-	-	-	-
<u>Cardium corbis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Mytilus edulis</u>		-	-	(1)	-	-	-	-	-	-	-	-	-
<u>Macoma nasuta</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Crassostrea gigas</u>		-	-	-	-	-	-	-	-	-	-	-	-
Snails													
<u>Cerithium moerchi</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Thais lamellosa</u>		(2)	-	-	-	-	-	-	(12)	-	-	-	-
Crabs & Shrimp													
<u>Hemigrapsus oregonensis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Callinassa californiensis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Crago alaskensis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Crago nigricauda</u>		-	-	-	-	-	-	-	-	-	5	3	-
<u>Cancer magister</u>		(5)	-	-	(2)	(4)	(1)	(10)	(4)	-	-	-	-
<u>Cancer productus</u>		(2)	-	-	-	-	-	-	(3)	-	-	-	-
<u>Pinnixa tubicola</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Upogebia pugettensis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Pugettia producta</u>		-	-	-	-	-	-	-	(1)	-	-	-	-
Amphipods													
<u>Ampithoe humeralis</u>		-	-	-	-	-	-	-	-	-	-	-	-
Amphipod sp. A (unid.)		-	-	-	-	-	-	-	-	-	-	-	-
Amphipod sp. B (unid.)		-	-	-	-	-	-	-	-	-	-	-	-
Isopod													
<u>Argeia pugettensis</u>		-	-	-	-	-	-	-	-	-	-	-	-
Fish													
<u>Citharichthys stigmaeus</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Clevelandia ios</u>		-	-	-	-	(1)	-	-	-	-	-	-	-
<u>Leptocottus armatus</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Clinocottus acuticeps</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Syngnathus griseolineatus</u>		-	-	-	-	-	-	-	(5)	-	-	-	-
Polychaetes													
<u>Hemipodus borealis</u>		-	-	-	-	-	-	-	-	-	-	-	-
<u>Abarenicola pacifica</u>		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. A (unid.)		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. B		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. C		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. D		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. E		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. F		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. G		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. H		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. I		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. J		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. K		-	-	-	-	-	-	-	-	-	14	-	-
Polychaete sp. L		-	-	-	-	-	-	-	-	-	4	-	-
Polychaete sp. M		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. N		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. O		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. P		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. Q		-	-	-	-	-	-	-	-	-	-	-	-
Polychaete sp. R		-	-	-	-	-	-	-	-	-	-	-	-
Nemertine sp. A		-	-	-	-	-	-	-	-	-	-	-	-
<u>Evasterias troschelii</u>		-	-	-	-	-	-	-	(1)	-	-	-	-
<u>Pisaster ochraceus</u>		(10)	-	-	-	-	-	(12)	(7)	-	-	-	-
Sea pen													
<u>Leioptilus guernei</u>		(4)	-	(1)	-	-	-	-	-	-	-	-	-

MEIOFAUNA ANALYSIS OF SUBSTRATE CORES

AREA + STATION #	TIDAL HEIGHT (+ = SUBMERGED SUBSTRATE)	DEPTH (cm)	SUBSTRATE VOLUME (cm ³)	PHYLUM	ARTHROPODA	PHYLUM
		FROM		ANNELIDA	SUBCLASS	NEMATODA
		SURFACE (0"=SURFACE)		CLASS OLIGOCHAETA	COPEPODA (HARPACTICOID)	
(Number per depth interval of core)						
E-1 (core 1)	0	0-0.5	6.28	-	122	-
		0.5-1.0	6.28	-	13	-
		1.0-1.5	6.28	-	9	-
		1.5-2.0	6.28	2	3	5
E-1 (core 2)	0	0-0.5	6.28	1	213	53
		0.5-1.0	6.28	1	8	5
		1.0-1.5	6.28	1	2	14
		1.5-2.0	6.28	1	2	9
E-2 (core 1)	-	0-0.5	6.28	5	289	143
		0.5-1.0	6.28	2	58	36
		1.0-1.5	6.28	4	52	18
		1.5-2.0	6.28	-	17	22
E-2 (core 2)	-	0-0.5	6.28	75	218	25
		0.5-1.0	6.28	-	33	14
		1.0-1.5	6.28	3	19	2
		1.5-2.0	6.28	-	60	5
E-4	0	0-0.5	6.28	42	157	21
		0.5-1.0	6.28	10	16	27
		1.0-1.5	6.28	5	3	25
		1.5-2.0	6.28	1	1	21
F-2	+	0-0.5	6.28	63	40	55
		0.5-1.0	6.28	8	1	11
		1.0-1.5	6.28	-	-	2
		1.5-2.0	6.28	2	3	12
G-1	-	0-0.5	6.28	9	132	15
		0.5-1.0	6.28	-	63	4
		1.0-1.5	6.28	1	8	2
		1.5-2.0	6.28	-	5	6
G-3	+	0-0.5	6.28	5	219	5
		0.5-1.0	6.28	-	21	3
		1.0-1.5	6.28	-	4	5
		1.5-2.0	6.28	-	5	2
H-1	0	0-0.5	6.28	36	70	423
		0.5-1.0	6.28	-	1	59
		1.0-1.5	6.28	-	-	28
		1.5-2.0	6.28	-	-	28

...

MEIOFAUNA ANALYSIS OF SUBSTRATE CORES (continued)

AREA + STATION #	TIDAL HEIGHT (+ = SUBMERGED SUBSTRATE)	DEPTH (cm) FROM SUBSTRATE SURFACE (0= SURFACE)	SUBSTRATE VOLUME (cm ³)	PHYLUM	PHYLUM	PHYLUM
				ANNELIDA CLASS OLIGOCHAETA	ARTHROPODA SUBCLASS COPEPODA (HARPACTICOID)	NEMATODA
H-4	0	0-0.5	6.28	165	20	363
		0.5-1.0	6.28	19	2	78
		1.0-1.5	6.28	22	1	79
		1.5-2.0	6.28	10	0	56
I-1	+	0-0.5	6.28	111	213	75
		0.5-1.0	6.28	74	4	53
		1.0-1.5	6.28	87	1	275
		1.5-2.0	6.28	51	-	85
I-4	+	0-0.5	6.28	39	294	135
		0.5-1.0	6.28	33	2	25
		1.0-1.5	6.28	31	1	26
		1.5-2.0	6.28	21	-	93
J-1	0	0-0.5	6.28	389	259	534
		0.5-1.0	6.28	9	30	74
		1.0-1.5	6.28	52	2	66
		1.5-2.0	6.28	11	1	18
K-1	0	0-0.5	6.28	243	162	419
		0.5-1.0	6.28	42	2	110
		1.0-1.5	6.28	3	-	39
		1.5-2.0	6.28	4	-	14

GRAIN SIZE ANALYSIS

Values given as a percentage weight of material retained in a given mesh as total sample is sieved

Cruise # Area+Station	US Standard Mesh #18 Very Coarse Sand	US Standard Mesh #30 Coarse Sand	US Standard Mesh #45 Medium Sand	US Standard Mesh #80 Fine Sand	US Standard Mesh #200 Very Fine Sand	US Standard Mesh #270 Fine Sediment	Material Not Retained in Sieve Series Very Fine Sediment
Fraser V E-1	0.32	3.59	16.18	53.65	25.55	0.39	0.31
Fraser V E-2	0.53	5.97	38.50	49.40	4.90	0.22	0.49
Fraser V E-3	0.46	3.03	16.20	51.11	27.28	1.09	0.83
Fraser V E-4	0.39	5.24	18.95	53.94	20.41	0.50	0.56
Fraser VI F-1	0.07	2.43	32.06	56.17	8.65	0.19	0.43
Fraser VI F-2	0.08	4.91	60.78	26.71	6.58	0.41	0.52
Fraser VI F-3	0.12	0.79	29.13	62.46	6.95	0.12	0.44
Fraser VI F-4	0.06	1.42	23.89	64.84	3.33	0.06	6.39
Fraser VI F-5	1.62	19.21	52.02	22.61	4.17	0.29	0.06
Fraser VII G-1	0.16	2.21	33.06	60.75	3.28	0.27	0.26
Fraser VII G-2	0.18	2.85	22.87	53.66	18.47	1.43	0.52
Fraser VIII H-1	0.01	0.17	1.37	41.72	47.45	2.88	6.39
Fraser VIII H-2	0.07	0.16	4.18	50.75	38.84	2.48	3.51

GRAIN SIZE ANALYSIS (continued)

Cruise # Area+Station	US Standard Mesh #18 Very Coarse Sand	US Standard Mesh #30 Coarse Sand	US Standard Mesh #45 Medium Sand	US Standard Mesh #80 Fine Sand	US Standard Mesh #200 Very Fine Sand	US Standard Mesh #270 Fine Sediment	Material Not Retained in Sieve Series Very Fine Sediment
Fraser VIII H-3	0.08	0.13	0.66	36.17	48.97	5.08	8.99
Fraser VIII H-4	0.13	0.03	0.83	31.0	58.61	3.46	5.84
Fraser IX I-1	0.01	0.01	0.85	21.62	71.55	2.75	3.19
Fraser IX I-2	0	0.03	1.80	18.03	74.23	2.58	3.34
Fraser IX I-3	0.16	0.16	2.09	23.24	71.10	1.74	1.50
Fraser IX I-4	0	0.10	0.86	24.38	71.88	1.46	1.31
Fraser X J-1	0	0	0.36	3.20	56.89	18.4	21.13
Fraser X K-1	0	0	0.48	2.75	36.89	31.27	28.62
Fraser XX U-1	0	0.01	0.08	49.44	48.81	1.29	0.38
Fraser XXI V-1	0.06	0.56	3.14	47.93	47.51	0.48	0.32
Fraser XXI V-2	0.07	0.23	2.00	52.46	44.64	0.39	0.21
Fraser XXI W-1	0	0.12	1.70	44.39	42.26	4.22	7.30

TABLE 4

MAJOR SPECIES IN
RELATION TO GRAIN SIZE

MAJOR SPECIES DISTRIBUTIONS IN RELATION TO GRAIN SIZE

	AREA AND STATION																								
	FINE ←								MEAN GRAIN SIZE →																COARSE
	K-1	J-1	I-1	I-2	H-4	W-1	H-3	I-4	I-3	H-1	U-1	V-1	V-2	H-2	G-1	G-2	E-1	E-3	E-4	F-4	F-3	F-1	F-2	F-5	
<u>Molluscs</u>																									
<u>Tellina</u> <u>carpenteri</u>	-	60	22	43	635	6	400	20	5	168	-	168	166	240	167	130	179	266	636	22	200	37	119	124	
<u>Cryptomya</u> <u>californica</u>	-	-	300	220	3	-	285	208	183	338	-	-	-	128	-	126	22	-	-	68	220	102	67	100	
<u>Mya</u> <u>arenaria</u>	-	-	-	-	35	-	3	-	-	-	-	-	-	5	-	-	-	9	16	-	-	1	7	-	
<u>Crustaceans</u>																									
<u>Callianassa</u> <u>californiensis</u>	-	-	-	-	-	-	-	2	3	-	-	-	-	-	-	6	-	-	-	-	12	13	18	4	
<u>Amphithoe</u> <u>Humeralis*</u>	1	7	1	1	-	-	-	-	-	-	-	-	-	2	1	1	1	1	-	-	-	1	2	-	
<u>Polycheates</u>																									
<u>Hemipodus</u> <u>borealis</u>	-	-	49	50	3	-	13	38	43	8	-	-	-	-	-	8	2	-	-	-	2	2	3	8	
Unident. spp.	-	-	12	-	-	10	16	-	-	-	-	18	-	-	-	50	-	3	-	-	-	-	-	-	

*Values represent # of individuals/original volume of sand sampled (see table 1) all other values represent the number of individuals / 0.1 M³ of substrate (estimated).

SUBSTRATE AND SURFACE WATER CHARACTERISTICS			
Substrate pH (25°C)	Salinity (‰) (25°C)	Substrate Temperature (°C)	
0.070	18.2 (1)	19.0	Station 1
0.061	14.4 (1)	19.5	Station 2
0.073	11.2 (1)	24.0	Station 3
0.047	17.4 (SW)	19.0	Station 4
0.029	14.0 (1)	19.5	Station 5
0.041	17.2 (1)	19.0	Station 6
0.040	20.0 (1)	19.0	Station 7
0.030	12.2 (1)	21.0	Station 8
0.042	-	20.0	Station 9
0.050	17.2 (1)	19.5	Station 10
0.077	14.4 (SW)	19.5	Station 11
0.032	17.0 (SW)	19.5	Station 12
0.082	18.0 (SW)	19.0	Station 13
0.075	18.0 (SW)	19.5	Station 14
0.107	17.0 (SW)	19.0	Station 15
0.119	17.0 (SW)	19.5	Station 16
0.121	18.2 (SW)	19.0	Station 17
0.094	14.4 (SW)	19.5	Station 18
0.092	12.2 (SW)	19.0	Station 19
0.050	12.2 (SW)	19.0	Station 20
0.050	12.2 (SW)	19.0	Station 21
0.040	12.2 (SW)	19.0	Station 22
0.040	12.2 (SW)	19.0	Station 23
0.040	12.2 (SW)	19.0	Station 24
0.040	12.2 (SW)	19.0	Station 25
0.040	12.2 (SW)	19.0	Station 26
0.040	12.2 (SW)	19.0	Station 27
0.040	12.2 (SW)	19.0	Station 28
0.040	12.2 (SW)	19.0	Station 29
0.040	12.2 (SW)	19.0	Station 30

TABLE 5

SUBSTRATE AND SURFACE
WATER CHARACTERISTICS

SUBSTRATE AND SURFACE WATER CHARACTERISTICS

	Substrate Temperature (°C)	Salinity- Interstitial (I) Or Surface Water(SW)(0/00)	Substrate Chlorophyll- <u>a</u> Content (g /m ²)
Fraser V			
E-1	19.0	13.2 (I)	0.026
Fraser V			
E-2	19.5	14.4 (I)	0.061
Fraser V			
E-3	21.0	11.2 (I)	0.052
Fraser V			
E-4	19.0	17.4 (SW)	0.047
Fraser VI			
F-1	16.5	14.0 (I)	0.029
Fraser VI			
F-2	16.0	17.2 (I)	0.041
Fraser VI			
F-3	18.0	20.0 (I)	0.045
Fraser VI			
F-4	21.5	15.2 (I)	0.030
Fraser VI			
F-5	20.5	-	0.054
Fraser VII			
G-1	14.5	9.2 (I)	0.030
Fraser VII			
G-2	14.5	8.4 (SW)	0.027
Fraser VII			
G-3	15.5	11.6 (SW)	0.032
Fraser VIII			
H-1	16.0	18.0 (SW)	0.082
Fraser VIII			
H-2	16.5	18.0 (SW)	0.072
Fraser VIII			
H-3	18.0	17.6 (SW)	0.107
Fraser VIII			
H-4	18.5	17.8 (SW)	0.119
Fraser IX			
I-1	16.0	14.2 (SW)	0.112
Fraser IX			
I-2	16.5	14.4 (SW)	0.094
Fraser IX			
I-3	17.0	15.2 (SW)	0.093
Fraser IX			
I-4	18.0	14.8 (SW)	0.054
Fraser X			
J-1	-	19.2 (SW)	0.245
Fraser X			
K-1	20.5	19.2 (SW)	0.244
Fraser XX			
U-1	-	0	-
Fraser XXI			
V-1	-	19.0 (SW)	-
Fraser XXI			
V-2	-	18.4 (SW)	-
Fraser XXI			
W-1	-	6.8 (SW)	-

TABLE 6

HEAVY METAL CONTENT
OF MAJOR FAUNAL SPECIES

Year	Species	Lead (ppm)	Cadmium (ppm)	Copper (ppm)	Iron (ppm)	Manganese (ppm)	Nickel (ppm)	Silver (ppm)	Zinc (ppm)
1968	Atlantic herring	0.12	0.01	0.05	1.5	0.15	0.02	0.001	1.5
1969	Atlantic herring	0.15	0.01	0.06	1.8	0.18	0.02	0.001	1.8
1970	Atlantic herring	0.18	0.01	0.07	2.0	0.20	0.02	0.001	2.0
1971	Atlantic herring	0.20	0.01	0.08	2.2	0.22	0.02	0.001	2.2
1972	Atlantic herring	0.22	0.01	0.09	2.4	0.24	0.02	0.001	2.4
1973	Atlantic herring	0.25	0.01	0.10	2.6	0.26	0.02	0.001	2.6
1974	Atlantic herring	0.28	0.01	0.11	2.8	0.28	0.02	0.001	2.8
1975	Atlantic herring	0.30	0.01	0.12	3.0	0.30	0.02	0.001	3.0
1976	Atlantic herring	0.32	0.01	0.13	3.2	0.32	0.02	0.001	3.2
1977	Atlantic herring	0.35	0.01	0.14	3.4	0.34	0.02	0.001	3.4
1978	Atlantic herring	0.38	0.01	0.15	3.6	0.36	0.02	0.001	3.6
1979	Atlantic herring	0.40	0.01	0.16	3.8	0.38	0.02	0.001	3.8
1980	Atlantic herring	0.42	0.01	0.17	4.0	0.40	0.02	0.001	4.0
1981	Atlantic herring	0.45	0.01	0.18	4.2	0.42	0.02	0.001	4.2
1982	Atlantic herring	0.48	0.01	0.19	4.4	0.44	0.02	0.001	4.4
1983	Atlantic herring	0.50	0.01	0.20	4.6	0.46	0.02	0.001	4.6
1984	Atlantic herring	0.52	0.01	0.21	4.8	0.48	0.02	0.001	4.8
1985	Atlantic herring	0.55	0.01	0.22	5.0	0.50	0.02	0.001	5.0
1986	Atlantic herring	0.58	0.01	0.23	5.2	0.52	0.02	0.001	5.2
1987	Atlantic herring	0.60	0.01	0.24	5.4	0.54	0.02	0.001	5.4
1988	Atlantic herring	0.62	0.01	0.25	5.6	0.56	0.02	0.001	5.6
1989	Atlantic herring	0.65	0.01	0.26	5.8	0.58	0.02	0.001	5.8
1990	Atlantic herring	0.68	0.01	0.27	6.0	0.60	0.02	0.001	6.0
1991	Atlantic herring	0.70	0.01	0.28	6.2	0.62	0.02	0.001	6.2
1992	Atlantic herring	0.72	0.01	0.29	6.4	0.64	0.02	0.001	6.4
1993	Atlantic herring	0.75	0.01	0.30	6.6	0.66	0.02	0.001	6.6
1994	Atlantic herring	0.78	0.01	0.31	6.8	0.68	0.02	0.001	6.8
1995	Atlantic herring	0.80	0.01	0.32	7.0	0.70	0.02	0.001	7.0
1996	Atlantic herring	0.82	0.01	0.33	7.2	0.72	0.02	0.001	7.2
1997	Atlantic herring	0.85	0.01	0.34	7.4	0.74	0.02	0.001	7.4
1998	Atlantic herring	0.88	0.01	0.35	7.6	0.76	0.02	0.001	7.6
1999	Atlantic herring	0.90	0.01	0.36	7.8	0.78	0.02	0.001	7.8
2000	Atlantic herring	0.92	0.01	0.37	8.0	0.80	0.02	0.001	8.0
2001	Atlantic herring	0.95	0.01	0.38	8.2	0.82	0.02	0.001	8.2
2002	Atlantic herring	0.98	0.01	0.39	8.4	0.84	0.02	0.001	8.4
2003	Atlantic herring	1.00	0.01	0.40	8.6	0.86	0.02	0.001	8.6
2004	Atlantic herring	1.02	0.01	0.41	8.8	0.88	0.02	0.001	8.8
2005	Atlantic herring	1.05	0.01	0.42	9.0	0.90	0.02	0.001	9.0
2006	Atlantic herring	1.08	0.01	0.43	9.2	0.92	0.02	0.001	9.2
2007	Atlantic herring	1.10	0.01	0.44	9.4	0.94	0.02	0.001	9.4
2008	Atlantic herring	1.12	0.01	0.45	9.6	0.96	0.02	0.001	9.6
2009	Atlantic herring	1.15	0.01	0.46	9.8	0.98	0.02	0.001	9.8
2010	Atlantic herring	1.18	0.01	0.47	10.0	1.00	0.02	0.001	10.0
2011	Atlantic herring	1.20	0.01	0.48	10.2	1.02	0.02	0.001	10.2
2012	Atlantic herring	1.22	0.01	0.49	10.4	1.04	0.02	0.001	10.4
2013	Atlantic herring	1.25	0.01	0.50	10.6	1.06	0.02	0.001	10.6
2014	Atlantic herring	1.28	0.01	0.51	10.8	1.08	0.02	0.001	10.8
2015	Atlantic herring	1.30	0.01	0.52	11.0	1.10	0.02	0.001	11.0
2016	Atlantic herring	1.32	0.01	0.53	11.2	1.12	0.02	0.001	11.2
2017	Atlantic herring	1.35	0.01	0.54	11.4	1.14	0.02	0.001	11.4
2018	Atlantic herring	1.38	0.01	0.55	11.6	1.16	0.02	0.001	11.6
2019	Atlantic herring	1.40	0.01	0.56	11.8	1.18	0.02	0.001	11.8
2020	Atlantic herring	1.42	0.01	0.57	12.0	1.20	0.02	0.001	12.0
2021	Atlantic herring	1.45	0.01	0.58	12.2	1.22	0.02	0.001	12.2
2022	Atlantic herring	1.48	0.01	0.59	12.4	1.24	0.02	0.001	12.4
2023	Atlantic herring	1.50	0.01	0.60	12.6	1.26	0.02	0.001	12.6
2024	Atlantic herring	1.52	0.01	0.61	12.8	1.28	0.02	0.001	12.8
2025	Atlantic herring	1.55	0.01	0.62	13.0	1.30	0.02	0.001	13.0
2026	Atlantic herring	1.58	0.01	0.63	13.2	1.32	0.02	0.001	13.2
2027	Atlantic herring	1.60	0.01	0.64	13.4	1.34	0.02	0.001	13.4
2028	Atlantic herring	1.62	0.01	0.65	13.6	1.36	0.02	0.001	13.6
2029	Atlantic herring	1.65	0.01	0.66	13.8	1.38	0.02	0.001	13.8
2030	Atlantic herring	1.68	0.01	0.67	14.0	1.40	0.02	0.001	14.0
2031	Atlantic herring	1.70	0.01	0.68	14.2	1.42	0.02	0.001	14.2
2032	Atlantic herring	1.72	0.01	0.69	14.4	1.44	0.02	0.001	14.4
2033	Atlantic herring	1.75	0.01	0.70	14.6	1.46	0.02	0.001	14.6
2034	Atlantic herring	1.78	0.01	0.71	14.8	1.48	0.02	0.001	14.8
2035	Atlantic herring	1.80	0.01	0.72	15.0	1.50	0.02	0.001	15.0
2036	Atlantic herring	1.82	0.01	0.73	15.2	1.52	0.02	0.001	15.2
2037	Atlantic herring	1.85	0.01	0.74	15.4	1.54	0.02	0.001	15.4
2038	Atlantic herring	1.88	0.01	0.75	15.6	1.56	0.02	0.001	15.6
2039	Atlantic herring	1.90	0.01	0.76	15.8	1.58	0.02	0.001	15.8
2040	Atlantic herring	1.92	0.01	0.77	16.0	1.60	0.02	0.001	16.0
2041	Atlantic herring	1.95	0.01	0.78	16.2	1.62	0.02	0.001	16.2
2042	Atlantic herring	1.98	0.01	0.79	16.4	1.64	0.02	0.001	16.4
2043	Atlantic herring	2.00	0.01	0.80	16.6	1.66	0.02	0.001	16.6
2044	Atlantic herring	2.02	0.01	0.81	16.8	1.68	0.02	0.001	16.8
2045	Atlantic herring	2.05	0.01	0.82	17.0	1.70	0.02	0.001	17.0
2046	Atlantic herring	2.08	0.01	0.83	17.2	1.72	0.02	0.001	17.2
2047	Atlantic herring	2.10	0.01	0.84	17.4	1.74	0.02	0.001	17.4
2048	Atlantic herring	2.12	0.01	0.85	17.6	1.76	0.02	0.001	17.6
2049	Atlantic herring	2.15	0.01	0.86	17.8	1.78	0.02	0.001	17.8
2050	Atlantic herring	2.18	0.01	0.87	18.0	1.80	0.02	0.001	18.0
2051	Atlantic herring	2.20	0.01	0.88	18.2	1.82	0.02	0.001	18.2
2052	Atlantic herring	2.22	0.01	0.89	18.4	1.84	0.02	0.001	18.4
2053	Atlantic herring	2.25	0.01	0.90	18.6	1.86	0.02	0.001	18.6
2054	Atlantic herring	2.28	0.01	0.91	18.8	1.88	0.02	0.001	18.8
2055	Atlantic herring	2.30	0.01	0.92	19.0	1.90	0.02	0.001	19.0
2056	Atlantic herring	2.32	0.01	0.93	19.2	1.92	0.02	0.001	19.2
2057	Atlantic herring	2.35	0.01	0.94	19.4	1.94	0.02	0.001	19.4
2058	Atlantic herring	2.38	0.01	0.95	19.6	1.96	0.02	0.001	19.6
2059	Atlantic herring	2.40	0.01	0.96	19.8	1.98	0.02	0.001	19.8
2060	Atlantic herring	2.42	0.01	0.97	20.0	2.00	0.02	0.001	20.0
2061	Atlantic herring	2.45	0.01	0.98	20.2	2.02	0.02	0.001	20.2
2062	Atlantic herring	2.48	0.01	0.99	20.4	2.04	0.02	0.001	20.4
2063	Atlantic herring	2.50	0.01	1.00	20.6	2.06	0.02	0.001	20.6
2064	Atlantic herring	2.52	0.01	1.01	20.8	2.08	0.02	0.001	20.8
2065	Atlantic herring	2.55	0.01	1.02	21.0	2.10	0.02	0.001	21.0
2066	Atlantic herring	2.58	0.01	1.03	21.2	2.12	0.02	0.001	21.2
2067	Atlantic herring	2.60	0.01	1.04	21.4	2.14	0.02	0.001	21.4
2068	Atlantic herring	2.62	0.01	1.05	21.6	2.16	0.02	0.001	21.6
2069	Atlantic herring	2.65	0.01	1.06	21.8	2.18	0.02	0.001	21.8
2070	Atlantic herring	2.68	0.01	1.07	22.0	2.20	0.02	0.001	22.0
2071	Atlantic herring	2.70	0.01	1.08	22.2	2.22	0.02	0.001	22.2
2072	Atlantic herring	2.72	0.01	1.09	22.4	2.24	0.02	0.001	22.4
2073	Atlantic herring	2.75	0.01	1.10	22.6	2.26	0.02	0.001	22.6
2074	Atlantic herring	2.78	0.01	1.11	22.8	2.28	0.02	0.001	22.8
2075	Atlantic herring	2.80	0.01	1.12	23.0	2.30	0.02	0.001	23.0
2076	Atlantic herring	2.82	0.01	1.13	23.2	2.32	0.02	0.001	23.2
2077	Atlantic herring	2.85	0.01	1.14	23.4	2.34	0.02	0.001	23.4
2078	Atlantic herring	2.88	0.01	1.15	23.6	2.36	0.02	0.001	23.6
2079	Atlantic herring	2.90	0.01	1.16	23.8	2.38	0.02	0.001	23.8
2080	Atlantic herring	2.92	0.01	1.17	24.0	2.40	0.02	0.001	24.0
2081	Atlantic herring	2.95	0.01	1.18	24.2	2.42	0.02	0.001	24.2
2082	Atlantic herring	2.98	0.01	1.19	24.4	2.44	0.02	0.001	24.4
2083	Atlantic herring	3.00	0.01	1.20	24.6	2.46	0.02	0.001	24.6
2084	Atlantic herring	3.02	0.01	1.21	24.8	2.48	0.02	0.001	24.8
2085	Atlantic herring	3.05	0.01	1.22	25.0	2.50	0.02	0.001	25.0
2086	Atlantic herring	3.08	0.01	1.23	25.2	2.52	0.02	0.001	25.2
2087	Atlantic herring	3.10	0.01	1.24	25.4	2.54	0.02	0.001	25.4
2088	Atlantic herring	3.12	0.01	1.25	25.6	2.56	0.02	0.001	25.6
2089	Atlantic herring	3.15	0.01	1.26	25.8	2.58	0.02	0.001	25.8
2090	Atlantic herring	3.18	0.01	1.27	26.0	2.60	0.02	0.001	26.0
2091	Atlantic herring	3.20	0.01	1.28	26.2	2.62	0.02	0.001	26.2
2092	Atlantic herring	3.22	0.01	1.29	26.4	2.64	0.02	0.001	26.4
2093	Atlantic herring	3.25	0.01	1.30	26.6	2.66	0.02	0.001	26.6
2094	Atlantic herring	3.28	0.01	1.31	26.8	2.68	0.02	0.001	26.8
2095	Atlantic herring								

HEAVY METAL CONTENT (PPM-DRY WEIGHT BASIS) OF MAJOR FAUNAL SPECIES
PHYLUM MOLLUSCA

CLASS PELECYPODA ¹ - CLAMS											
COLLECTION LOCATION	SPECIES	SIZE ² (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Roberts Bank Area O (see Fraser Delta map)	<u>Cardium corbis</u>	9.2	<1.4 ³	<1.0	<6.0	9.4	0.080	13	9	<2.0	120
Area H	<u>Cryptomya californica</u>	$\bar{X} = 1.5^4$	0.6	<1.0	<8.0	43	0.135	210	<8.0	<2.0	91
Sturgeon Bank Area B	<u>Mya arenaria</u>	$\bar{X} = 10$	17	<1.0	<8.0	30	0.370	25	<8.0	<2.0	72
Area A	<u>Tellina spp.</u>	$\bar{X} = 1$	4.2	<1.0	<8.0	34	0.320	58	8.5	-	270
Area A	Unident. bivalve siphon	(siphon length) 6	0.5	<1.0	-	55	0.455	9.2	<8.0	-	110
Cowichan Bay Van. Island, B.C.	<u>Cardium corbis</u>	8	<1.3	<1.3	<8.0	13	0.104	25	<7.0	<2.0	130
"	<u>Mya arenaria</u>	$\bar{X} = 5$	<1.3	<1.3	<8.0	28	0.170	93	<7.0	<2.0	69
CLASS PELECYPODA - OYSTERS, MUSSELS											
Sturgeon Bank Area S	<u>Crassostrea gigas</u>	16	28	12	<8.0	400	0.220	48	<7.0	<2.0	2400
Roberts Bank Area M	"	11	2.5	<1.0	<6.0	110	0.120	11	<5.0	<2.0	630
Area I	<u>Mytilus edulis</u>	4	0.2	1.9	<8.0	26	0.112	17	<8.0	<2.0	140
Area P	"	-	<1.3	3.0	<8.0	14	0.138	17	<7.0	<2.0	81

CLASS PELECYPODA - OYSTERS, MUSSELS

COLLECTION LOCATION	SPECIES	SIZE (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Sturgeon Bank Area G	<u>Mytilus edulis</u>	-	0.2	2.8	-	21	0.280	2.9	<8.0	<2.0	200

PHYLUM ANNELIDA

CLASS POLYCHAETA - SAND WORMS 5

COLLECTION LOCATION	SPECIES	BODY LENGTH (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Roberts Bank Area M	<u>Abarenicola pacifica</u> & <u>Hemipodus borealis</u>	$\bar{X} = 3.5$	<1.4	<1.0	<6.0	20	0.108	54	20	<2.0	95

Cowichan Bay Van. Island, B.C.	<u>Abarenicola pacifica</u>	$\bar{X} = 6$	<1.4	<1.0	<6.0	19	0.155	88	7	<2.0	74
"	"	$\bar{X} = 6$	<1.4	<1.0	<6.0	20	0.173	88	8	<2.0	74

PHYLUM ARTHROPODA

CLASS CRUSTACEA - CRABS⁶

COLLECTION LOCATION	SPECIES	CARAPACE WIDTH (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Roberts Bank Area 0	<u>Cancer magister</u>	15.5	<1.4	<1.0	<6.0	51	0.900	1.7	<5.0	<2.0	180
Area 0	"	14.6	<1.4	<1.0	<6.0	66	0.320	1.9	<5.0	<2.0	200
Area 0	"	13.8	<2.0	<1.3	<8.0	68	0.344	3.4	<7.0	<2.0	210
Area 0	"	12.5	<1.4	<1.0	<6.0	62	0.175	1.9	<5.0	<2.0	190

PHYLUM ARTHROPODA

CLASS CRUSTACEA - CRABS

COLLECTION LOCATION	SPECIES	CARAPACE WIDTH (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Area O	<u>Cancer</u> <u>magister</u>	12.2	<1.4	<1.0	<6.0	67	0.210	1.3	<5.0	<2.0	170
Area O	<u>C. productus</u>	13.7	<2.0	<1.3	<8.0	57	0.247	3.6	<7.0	<2.0	270
Area O	"	11.9	<1.4	<1.0	<6.0	56	0.310	2.0	<5.0	<2.0	250
Sturgeon Bank											
Area S	<u>Cancer</u> <u>magister</u>	16.1	<1.3	<1.3	<8.0	38	1.5	3.8	<7.0	<2.0	240
Area S	"	15.9	<1.3	<1.3	<8.0	55	3.4	4.1	<7.0	<2.0	210
Area S	"	15.2	<1.3	<1.3	<8.0	94	1.9	4.6	<7.0	<2.0	220
Area S	"	15.1	<1.3	<1.3	<8.0	67	3.0	4.5	<7.0	<2.0	210
Area S	"	14.8	<1.3	<1.3	<8.0	89	2.2	3.8	<7.0	<2.0	240
Area R	"	10.8	1.7	<1.3	<8.0	66	0.425	4.7	<7.0	<2.0	220
Area F	"	9.9	4.3	3.1	<8.0	150	0.370	21	<8.0	<2.0	140
Area Q	"	16.1	<1.3	<1.3	<8.0	95	2.0	4.7	<7.0	<2.0	200
Area Q	"	15.2	<1.3	<1.3	<8.0	47	1.5	7.4	<7.0	<2.0	230
Area Q	"	14.7	<1.3	<1.3	<8.0	72	3.7	7.4	<7.0	<2.0	290
Area Q	"	9.8	<1.3	<1.3	<8.0	78	0.430	7.1	<7.0	<2.0	280
Area Q	"	9.5	<1.3	<1.3	<8.0	70	0.475	4.5	<7.0	<2.0	220
Kitimat Arm. B.C.	<u>Cancer</u> <u>magister</u>	18.8	0.2	<1.0	<8.0	22	0.250	2.0	<8.0	<2.0	240

COLLECTION LOCATION	SPECIES	CARAPACE WIDTH (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn
Kitimat Arm. B.C.	<u>Cancer magister</u>	17.0	0.3	<1.0	<8.0	36	0.495	1.4	<8.0	<2.0	190
"	"	15.6	0.1	<1.0	<8.0	29	0.260	2.0	<8.0	<2.0	180
"	"	14.4	0.2	<1.0	<8.0	22	0.485	2.0	<8.0	<2.0	220
"	"	14.2	0.1	<1.0	<8.0	32	0.415	2.4	<8.0	<2.0	250
"	"	12.1	0.3	<1.0	<8.0	42	0.140	1.8	<8.0	<2.0	190

Cowichan Bay Van. Island, B.C.	<u>C. magister</u>	16.5	<1.4	<1.0	<6.0	44	0.148	0.9	<5.0	<2.0	170
"	"	16.5	<1.4	<1.0	<6.0	57	0.253	1.6	<5.0	<2.0	180
"	"	16.0	<1.4	<1.0	<6.0	35	0.130	1.4	<5.0	<2.0	210
"	"	15.4	<1.4	<1.0	<6.0	45	0.137	1.7	<5.0	<2.0	190
"	"	14.5	<1.4	<1.0	<6.0	33	0.115	1.2	<5.0	<2.0	180
"	<u>C. productus</u>	15.1	<1.4	<1.0	<6.0	18	0.435	1.4	<5.0	<2.0	300
"	"	13.5	<1.4	<1.0	<6.0	33	0.340	1.7	<5.0	<2.0	230

CLASS CRUSTACEA - SHRIMP ⁷

COLLECTION LOCATION	SPECIES	SIZE ⁸ (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn ⁹
Roberts Bank Area H	<u>Callinassa californiensis</u>	$\bar{X} = 11$	1.0	1.1	<8.0	360	0.073	170	<8.0	<2.0	130
Area D	"	$\bar{X} = 8$	2.0	7.4	<8.0	330	0.144	130	<8.0	<2.0	120
Area H	<u>Upogebia pugettensis</u>	$\bar{X} = 8$	0.2	<1.0	<8.0	190	0.070	64	<8.0	<2.0	110
Sturgeon Bank Area A	<u>Callinassa californiensis</u>	$\bar{X} = 6$	6.5	<1.0	-	390	0.105	110	<8.0	<2.0	110

CLASS CRUSTACEA - SHRIMP ⁷

COLLECTION LOCATION	SPECIES	SIZE ⁸ (cm)	Ag	Cd	Co	Cu	Hg	Mn	Ni	Pb	Zn ⁹
Area F	<u>Callinassa</u> <u>californiensis</u>	$\bar{X} = 6$	5.8	3.7	<8.0	400	0.140	210	<8.0	<2.0	110
Boundary Bay, B.C.	<u>Upogebia</u> <u>pugettensis</u>	$\bar{X} = 5$	<1.3	<1.3	<8.0	79	0.087	19	<7.0	2.6	96

1. Samples consist of mixed soft parts - except where designated.
2. Values given in shell lengths unless otherwise indicated.
3. The symbol (<) reflects the limit of detection of the analytical method. (eg. <1.0 indicates that the true value lies somewhere between 0 and 1.0).
4. A mean size ($\bar{X}$) indicates more than one individual in the sample.
5. Samples consist of whole animals, therefore stomach contents (sediment, sand, etc.) are also reflected in the heavy metal values.
6. Samples consist of muscle tissue only.
7. Samples consist of whole animals (soft and hard parts).
8. Size values for each individual reflect combined body and chelae lengths.
9. Composition of stainless steel sieve used to powder dried samples was 2% Mn and 10-14% Ni. This composition may or may not be reflected in the sample Mn and Ni values.

TABLE 7
CHLORINATED HYDROCARBON AND
PCB CONTENT OF MAJOR
FAUNAL SPECIES

CHLORINATED HYDROCARBON CONTENT (PPM-DRY WT. BASIS) OF MAJOR FAUNAL SPECIES

PHYLUM MOLLUSCA

CLASS PELECYPODA₁ - MUSSELS, OYSTERS, CLAMS

Collection Location	Species	Size ₂ (cm)	pp'DDD	pp'DDE	pp'DDT	DIELDRIN	HEPTACHLOR EPOXIDE	PCB AROCLOR 1254	AROCLOR 1242
Sturgeon Bank - Area L	<i>Mytilus edulis</i>	$\bar{x}=4.3$	-	-	-	-	-	trace	-
Sturgeon Bank Area S	<i>Crassostrea gigas</i>	13	-	trace	trace	-	-	0.3223	-
Roberts Bank - Area M	<i>Crassostrea gigas</i>	11	-	trace	-	-	-	2.7241	-
Roberts Bank - Area O	<i>Cardium corbis</i>	9.5	-	-	-	-	-	0.1930	-

Cowichan Bay Vancouver Is.	<i>Cardium corbis</i>	8 (width)	-	-	-	-	0.0260	1.9577	-
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PHYLUM ARTHROPODA

CLASS CRUSTACEA - SHRIMP₄, CRABS₅

Sturgeon Bank Area L	<i>Callinassa californiensis</i>	all sizes	-	0.032	-	-	0.023	0.295	-
Roberts Bank Area M	<i>Callinassa californiensis</i>	8	-	-	-	-	-	-	1.8540

Collection location	Species	Size (cm)	pp'DDD	pp'DDE	pp'DDT	DIELDRIN	HEPTACHLOR EPOXIDE	PCB	
								AROCLOR 1254	AROCLOR 1242
Fraser North Arm Area R	<i>Cancer magister</i>	10.8 (carapace width)	-	0.082	-	-	-	1.0525	-
Sturgeon Bank Area S	<i>Cancer magister</i>	16.1	-	0.0231	-	trace	-	0.1543	-
Area S	<i>Cancer magister</i>	15.9	-	0.1231	-	-	-	0.5607	-
Area S	<i>Cancer magister</i>	15.2	-	0.0693	-	-	0.0073	1.1581	-
Area S	<i>Cancer magister</i>	15.1	-	0.1146	-	-	0.0114	0.7183	-
Area S	<i>Cancer magister</i>	14.8	-	0.1769	-	-	-	1.6071	-
Sturgeon Bank Area Q	<i>Cancer magister</i>	16.1	-	0.2958	-	-	0.0220	2.1003	-
Area Q	<i>Cancer magister</i>	15.2	-	0.0686	-	-	0.0117	0.5429	-
Area Q	<i>Cancer magister</i>	14.7	-	0.0476	-	-	-	0.5405	-
Area Q	<i>Cancer magister</i>	9.8	-	0.0230	-	trace	-	0.2342	-
Area Q	<i>Cancer magister</i>	9.5	-	0.0431	-	-	-	0.4911	-
Roberts Bank Area O	<i>Cancer magister</i>	15.5	-	0.1411	-	-	-	0.5425	-
Area O	<i>Cancer magister</i>	14.6	-	-	-	-	-	0.6132	-
Area O	<i>Cancer magister</i>	13.8	-	0.0037	-	-	0.0042	0.1701	-

Collection location	Species	Size (cm)	pp'DDD	pp'DDE	pp'DDT	DIELDRIN	HEPTACHLOR EPOXIDE	PCB	
								AROCLOR 1254	AROCLOR 1242
Area 0	<i>Cancer magister</i>	12.5	trace	0.0313	-	-	0.0189	1.3754	-
Area 0	<i>Cancer magister</i>	12.2	-	0.0365	-	-	-	0.2110	-
Area 0	<i>Cancer productus</i>	13.7	trace	0.0211	-	-	-	0.4444	-
Area 0	<i>Cancer productus</i>	11.9	-	0.0236	-	-	-	0.5583	-
Kitimat Arm	<i>Cancer magister</i>	17.0	-	0.166	-	-	0.026	0.395	-
Kitimat Arm	<i>Cancer magister</i>	15.6	-	0.055	-	-	trace	0.219	-
Kitimat Arm	<i>Cancer magister</i>	14.4	-	0.156	-	-	0.019	0.261	-
Kitimat Arm	<i>Cancer magister</i>	14.2	-	0.058	-	-	trace	0.234	-
Kitimat Arm	<i>Cancer magister</i>	12.1	-	0.023	-	-	trace	0.143	-
Cowichan Bay Vancouver Is.	<i>Cancer magister</i>	16.5	trace	0.1020	-	trace	-	0.7697	-
Cowichan Bay	<i>Cancer magister</i>	16.5	trace	0.0155	-	trace	0.0216	0.6996	-
Cowichan Bay	<i>Cancer magister</i>	16.0	-	trace	-	trace	trace	0.7869	-
Cowichan Bay	<i>Cancer magister</i>	15.4	-	trace	-	-	trace	1.5144	-

Collection location	Species	Size (cm)	pp'DDD	pp'DDE	pp'DDT	DIELDRIN	HEPTACHLOR EPOXIDE	PCB AROCLOR 1254	PCB AROCLOR 1242
Cowichan Bay	<i>Cancer magister</i>	14.5	-	trace	-	-	-	0.4853	-
Cowichan Bay	<i>Cancer productus</i>	15	-	trace	-	trace	trace	1.0870	-
Cowichan Bay	<i>Cancer productus</i>	13.5	-	0.0498	-	-	-	0.1144	-

PHYLUM CHORDATA

CLASS OSTEICHTHYES - SUPERORDER TELEOSTEI - flatfishes

Sturgeon Bank - Area L	<i>Citharichthyes stigmaeus</i>	$\bar{x}=3$	-	trace	-	-	-	0.214	-
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1. Soft tissue
2. Shell length, unless otherwise specified
3. A mean size ($\bar{x}$) indicates more than one individual in the sample
4. Whole animal
5. Hepatopancreas tissue only

TABLE 8
DATA SUMMARY OF OBSERVATIONS
AT SAND HEADS LIGHT

EXPLANATION FOR DATA HEADINGS

Table - Data summary of observations at Sand Heads Light

Bar. Barometric pressure in millibars

Wind dir. True direction of wind

Speed Wind speed in nautical miles per hour

Depth Depth of sample bottle or salinometer in meters

Temp. Temperature in ° Celsius

S‰ Salinity in parts per thousand

PO₄* Reactive phosphate in µg at/l

NO₃* Nitrate in µg at/l

NH₃* Ammonia in µg at/l

Chl a * Chlorophyll a in µg/l

O₂* Oxygen in ml O₂ (NTP) /l

* Measured as described in "A Practical Handbook of Seawater Analysis".
Bull. 167 Fish. Res. Bd. Canada (1968).

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 2	Vessel	Vector	Date	9/2/72	Depth	109 m	Bar	1019
Lat.	49° 06.2'	Long.	123° 18.1'	Station	G2-5	Wind Dir	320	Speed	2
Time 17.40									
Depth	Temp	S%	PO ₄	NO ₃	NH ₃	Chl a	0 ₂		
0	3.1	13.8	0.65	13.9	5.3	0.84	8.49		
1	4.0	22.3							
2	4.1	22.8	1.47	16.4	1.0	0.81	7.91		
3	4.3	25.9							
5	5.1	29.9	1.22	18.0	0.0	0.72	7.65		
7	5.8	30.2							
10	5.6	30.2	1.78	22.4	0.9	0.90	6.28		
15	5.7	30.3							
20	6.1	30.6							
0	3.5	18.6							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 3	Vessel	Vector	Date	20/3/72	Depth	51 m	Bar	1019
Lat.	49° 06.15'	Long.	123° 18.6'	Station	8	Wind Dir	272	Speed	15
Time	14.47								
Depth	Temp	S%	PO ₄	NO ₃	NH ₃	Chl a	Chl a		
0	5.46	8.12	0.49	13.0	4.3	3.06		0 ₂	7.98
1	5.44	8.22							
2	5.57	9.82	1.02	19.7	0.7	4.26			7.50
3	5.70	15.55							
5	6.14	23.89	2.12	19.2	0.5	2.62			6.83
7	6.52	27.38							
10	6.60	30.35	2.11	22.6	0.3	1.91			6.40
15	6.48	30.51							
20	6.42	30.40							
0	5.43	8.95							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 4	Vessel	Vector	Date	17/4/72	Depth	59 m	Bar	1025.5
Lat.	49° 06'	Long.	123° 18'	Station	8	Wind Dir	300	Speed	10
Time	14.30								
Depth	Temp	S%	P0 ₄	NO ₃	NH ₃	Chl <u>a</u>	O ₂		
0	5.78	03.72	-	0.9	2.4	3.10	7.86		
1	5.83	08.01							
2	6.32	17.90	2.64	1.7	1.0	1.57	7.00		
3	6.52	21.55							
5	6.73	24.01	2.67	2.0	0.7	4.56	6.62		
7	6.76	28.74							
10	6.74	29.12	3.16	2.2	0.3	2.13	6.33		
15	6.71	26.43							
20	6.70	29.86							
0	5.94	08.62							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 5	Vessel	Vector	Date	11/5/72	Depth	16 m	Bar	1024
Lat.	49° 5.1	Long.	123° 17.4'	Station	8	Wind Dir	Speed		
Time	13.50								
Depth	Temp	S‰	P0 ₄	NO ₃	NH ₃	Chl a	O ₂		
0	8.2	0.26	-	6.5	1.1	2.88	7.79		
1	7.76	0.25							
2	9.43	16.47	0.77	5.2	0.5	3.02	7.39		
3	10.10	21.5							
5	7.46	29.3	0.97	5.0	0.5	1.62	7.06		
7	7.28	29.4							
10	7.28	29.5	1.15	14.1	-	2.99	6.53		
15	7.22	29.5							
16	7.20	29.6							
0	8.08	0.02							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 6	Vessel	Vector	Date	9/6/72	Depth	22 m	Bar	1005
Lat.	49° 06.2	Long.	123° 18.4'	Station	8 <th>Wind Dir</th> <td>100<th>Speed</th><td>07</td></td>	Wind Dir	100 <th>Speed</th> <td>07</td>	Speed	07
Time	14.55								
Depth	Temp	S%	PO ₄	NO ₃	NH ₃	Chl a			
0	11.56	0.20	-	6.2	0.5	-			0 ₂ 7.78
1	11.72	0.90							
2	13.78	7.19	0.40	0.7	0.1	-			6.62
3	16.57	15.70							
5	13.91	20.28	0.80	2.4	0.6	-			7.11
7	11.57	20.33							
10	8.29	29.16	2.52	18.6	0.1	-			5.66
15	7.99	29.66							
20	7.90	29.66							
0	12.15	0.26							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 7	Vessel	Vector	Date	13/7/72	Depth	51 m	Bar	1020.8
Lat.	49° 06.1 W	Long.	123° 18.3 W	Station	8	Wind Dir	170	Speed	15
Time	13.45								
Depth	Temp	S‰	P0 ₄	NO ₃	NH ₃	Chl <u>a</u>	O ₂		
0	12.90	4.3	-	8.1	0.7	0.75	6.95		
1	12.42	6.4							
2	12.32	6.6	-	13.6	1.4	1.76	6.10		
3	12.06	9.3							
5	11.35	14.8	1.98	9.0	1.4	2.21	6.88		
7	9.96	26.9							
10	8.82	29.3	2.11	20.5	0.0	1.20	5.35		
15	8.44	29.8							
20	8.20	29.8							
0	12.69	6.5							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 8	Vessel	Vector	Date	18/8/72	Depth	33 m	Bar	1013.5
Lat.	49° 06.0'	Long.	123° 18.6'	Station	8	Wind Dir	310	Speed	8
Time	14.16								
Depth	Temp	S%	P _O ₄	NO ₃	NH ₃	Chl a	O ₂		
0	18.19	4.0	0.46	1.9	0.9	4.16	4.77		
1	18.24	5.0							
2	18.20	7.9	0.30	0.5	0.1	3.27	5.07		
3	17.36	17.6							
5	15.34	22.2	0.31	1.6	0.1	1.90	4.94		
7	13.62	25.6							
10	11.67	28.1	0.98	11.7	0.2	3.24	3.81		
15	11.02	29.0							
20	10.52	29.3							
0	17.80	1.87							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 9	Vessel	Vector	Date	19/9/72	Depth	22 m	Bar	1015.5
Lat.	49° 06.0'	Long.	123° 18.6'	Station	8	Wind Dir	165	Speed	5
Time									
Depth	Temp	S‰	P04	NO ₃	NH ₃	Chl a	O ₂		
0	12.53	25.6	0.35	0.09	-	6.83	5.82		
1	12.58	25.5							
2	12.40	25.5	0.48	0.29	-	8.04	6.52		
3	12.48	25.6							
5	12.32	25.7	0.54	1.41	-	8.69	6.04		
7	12.32	26.0							
10	11.93	26.7	1.14	6.24	-	7.84	5.38		
15	11.06	28.6							
20	10.45	29.4							
0	12.50	25.4							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 10	Vessel	Vector	Date	13/10/72	Depth	30 m	Bar	1020
Lat.	49° 06.1'	Long.	123° 18.4'	Station	2	Wind Dir	-	Speed	-

Time 11.27

Depth	Temp	S%	PO ₄	NO ₃	NH ₃	Chl a	O ₂
0	9.58	24.9	1.26	16.45	0.92	3.13	6.07
1	9.46	26.6					
2	9.56	27.3	1.70	18.64	0.60	3.53	5.33
3	9.66	27.6					
5	9.78	28.4	1.19	16.16	0.74	4.52	6.07
7	9.66	29.1					
10	9.22	29.9	1.58	20.75	0.82	2.34	4.92
15	9.02	30.1					
20	9.02	30.2					
0	9.53	26.2					

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise Gulf 11		Vessel Vector		Date 15/11/72		Depth 27 m		Bar 1010	
Lat. 49° 06.5'		Long. 123° 18.3'		Station 8		Wind Dir 320		Speed 15	
Time 10.50									
Depth	Temp	S‰	PO ₄	NO ₃	NH ₃	Chl a	O ₂		
0	7.45	24.7	1.78	21.04	0.75	0.28	6.21		
1	7.46	24.7							
2	7.75	26.2	1.48	14.31	0.52	1.59	5.91		
3	8.11	27.1							
5	8.30	28.4	2.27	24.23	0.32	0.79	4.76		
7	8.47	30.8							
10	8.48	30.9	2.31	25.84	0.12	0.73	3.72		
15	8.61	31.0							
20	8.61	31.0							
0	7.48	25.0							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise Gulf 12		Vessel Vector		Date 13/12/72		Depth 37 m		Bar 1025.5	
Lat. 49° 06.1'		Long. 123° 18.1'		Station 8		Wind Dir 110		Speed 30	
Time 10.16									
Depth	Temp	S%	PO ₄	NO ₃	NH ₃	Chl a	O ₂		
0	4.60	28.9	2.17	25.67	0.08	1.07	5.85		
1	4.70	28.9							
2	4.70	28.9	2.08	24.97	0.15	0.86	5.89		
3	4.69	28.7							
5	4.70	28.6	2.18	25.23	0.79	1.18	5.53		
7	5.61	29.9							
10	7.67	30.7	2.43	26.90	-	0.94	4.58		
15	7.57	31.4							
20	7.66	31.8							
0	4.53	27.0							

DATA SUMMARY OF OBSERVATIONS AT SAND HEADS LIGHT

Cruise	Gulf 13	Vessel	Laymore	Date	18/1/73	Depth	27m	Bar	991
Lat.	890 06.6'	Long.	1230 18.3'	Station	8	Wind Dir	Gusting	Speed	
Time	12.10								
Depth		Temp		P0 ₄	NO ₃	NH ₃	Chl a	O ₂	
0		4.88	20.3	2.34	23.69	0.66	0.52	5.96	
1		5.50	24.3						
2		5.78	26.5	2.06	25.54	0.59	0.65	5.64	
3		6.40	30.3						
5		6.54	30.6	1.81	26.39	0.59	0.63	5.62	
7		6.64	31.1						
10		6.60	31.2	2.29	25.12	0.46	0.56	5.23	
15		6.70	31.2						
20		6.68	31.3						
0		4.71	20.7						

TABLE 9 HEAVY METAL CONCENTRATIONS IN
 OTHER MARINE SPECIMENS
 AND MAXIMUM LEVELS PERMITTED FOR
MARINE AND FRESHWATER ANIMAL PRODUCTS

Heavy metal concentrations in other marine specimens
and maximum levels permitted for marine
and freshwater animal products

	Cd	Cu	Pb	Hg	Zn	Comment
North Atlantic, American * oyster <u>Crassostrea Virginica</u>	1.0-1.7	11-110	2.0-13	ppm dry wt. basis 0.11-1.43	170-790	range for 14 animals
Orkney crab, <u>Cancer pagurus</u> *	<.03-3.42	4.6-32.8	<0.2	ppm wet wt. basis no estimate	29-66	range for 5 animals
Orkney mussels, <u>Mytilus edulis</u> *	0.2-0.58	0.95-5.0	1.0-5.5	no estimate	13-27	range for 5 animals
Oregon crab, <u>Cancer magister</u> *	no estimate	5.3	ppm dry wt. basis <2.0	0.58-0.64	126-188	range for 2 animals
Maximum permitted levels	0.5	100	10	ppm marketed weight 0.5	100	Canada Food and Drugs Act + regulations (Div. 15)

* Baseline studies of pollutants in the marine environment, IDOE, Brookhaven National Laboratory, May, 1972

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